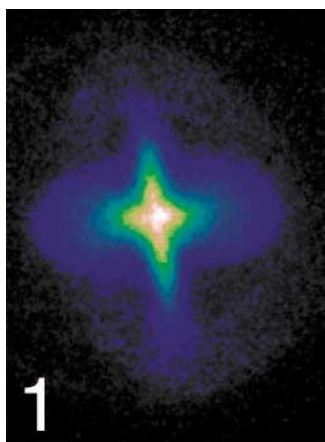


## Optical Diagnostics for HIF beam experiments

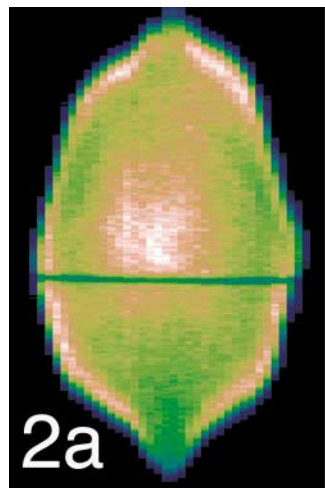
Optical imaging of the beams in HIF experiments, using glass and ceramic scintillators, has led to new diagnostic tools of great capability and flexibility [HIF News, Dec. 2001]. Such imaging enhances the speed and quality of data acquisition by providing a complete high-resolution two-dimensional image of the beam in a single pulse, in contrast to the thousands of beam pulses required by a crossed-slit scan. We have implemented optical diagnostics on HCX and NTX, and are beginning to exploit their capabilities.



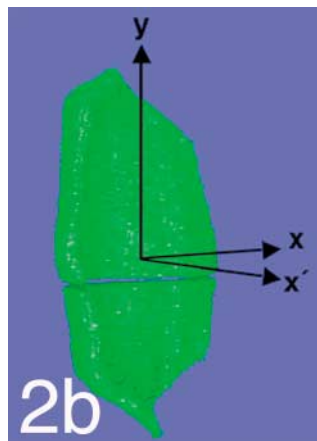
Time-resolved images of the beam striking the scintillator screen are captured with a gated and intensified CCD camera. A mesh placed in the path of the beam provides charge-neutralizing electrons to the scintillator material. The mesh may be grounded, or biased negative to minimize undesired light emission from stray energetic electrons striking the scintillator. Detailed comparisons show agreement with slit scanner measurements taken on HCX. A full time history of the beam pulse can be developed by gating different time windows on multiple pulses.

Figure 1 shows a typical image of the beam spatial profile, taken on NTX. In addition to imaging the beam in 2 dimensions, it is possible to pass the beam through a movable slit and combine the data obtained over multiple pulses. Such an “optical slit” diagnostic yields 3-D projections, such as  $f(x,y,x')$ , of the particle distribution  $f(x,y,x',y')$  in the 4-D transverse phase space. New information, such as the thermal spread as a function

of position in the cross-section,  $V_{\text{thermal},x}(x,y)$ , is directly available. Fig. 2(a) shows an HCX beam intensity profile based on an optical slit scan, referred to the horizontal slit plane. A 3-D representation of the iso-surface on which  $f(x,y,x')$  is equal to 30% of its peak is shown in fig. 2(b). The raised and curled edges of this representation are indicative of an s-shaped warping of the beam particle distribution in phase space.



Optical diagnosis also provides 4-D information by passing the beam through pinholes and imaging the particles striking the scintillator. The images provide information, for example, on local correlations in phase space between  $x'$  and  $y'$ , and on aberrations in the beam transport system. Since pinhole data is necessarily sampled only at pinhole locations, a combination of several different optical techniques is desirable.



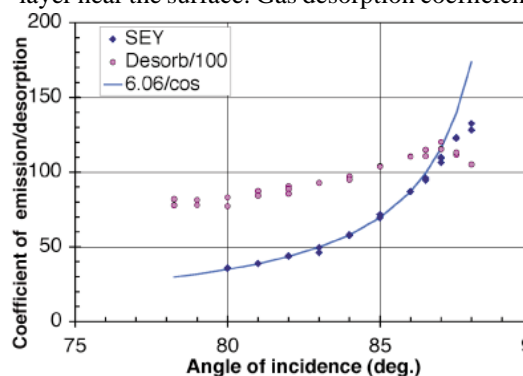
LBNL-PUB-844-03-05

Current work includes development of a compact optical diagnostic, and studies of the effects of optical emissions from beam-created plasma on the front face of the scintillator. In addition, improved algorithms for data analysis and interpretation are being developed; this research includes the development of capabilities for tomographic synthesis of the 4-D transverse distribution function from multiple 3-D views, to allow detailed

discrete-particle simulation of the beam dynamics in the downstream system. - *Frank Bieniosek and Alex Friedman*

## Experiments on electron and gas emission from a surface bombarded by heavy-ion beam

Accelerators for heavy-ion inertial fusion energy (HIF) have an economic incentive to fit beam tubes tightly to beams. This places them at risk from gas desorption runaway, and from electron clouds produced by secondary electrons and ionization of gas. We use the Gas-Electron Source Diagnostic (GESD) on the High Current Experiment (HCX) at LBNL to measure the flux of electrons and gas evolved when a 1 MeV  $K^+$  beam impinges a stainless steel target, whose angle can be varied between  $78^\circ$  and  $88^\circ$  from normal incidence. The results show that electron emission yield (SEY) scales with  $1/\cos(\theta)$  to within a few degrees of grazing incidence, consistent with emission from a thin layer near the surface. Gas desorption coefficients are larger, of order



ten thousand, and vary more slowly with angle. The latter indicates that most desorption is not from beam interaction with multiple monolayers of gas on the surface. We are investigating other possible sources of gas, and

are testing the applicability of models predicting that both electron and gas emission scale with electronic energy loss ( $dE/dx$ ) of ions. This understanding will be applied to mitigating the effects of gas and electrons.

We apply the measured electron-emission coefficients, from the GESD, to infer beam-halo loss from electron emission current in four quadrupole magnets that are installed on the HCX. From this, with gas-desorption coefficients, we will infer the associated gas desorption. - *Art Molvik*